Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

BULLETIN

OF THE

AMERICAN GEOGRAPHICAL SOCIETY

Vol. XLII 1910 No. 1

THE SOUTH MAGNETIC POLE*

THE MAGNETIC INCLINATION AND DECLINATION IN THE APPROACHES TO IT, AS DEDUCED FROM OBSERVATIONS MADE IN 1840 BY THE UNITED STATES EXPEDITION COMMANDED BY LIEUT. CHARLES WILKES, U.S.N.

BY

G. W. LITTLEHALES

The Congress of the United States, having in view the extension of the empire of commerce and science, by an Act of the 14th of May, 1836, authorized an expedition to be fitted out for the purpose of exploring and surveying in the Pacific Ocean and the South Seas; and on the 10th of August, 1838, the sloops-of-war *Vincennes* and *Peacock*, the ship *Relief*, the brig *Porpoise*, and the tenders *Sea Gull* and *Flying Fish*, composing the squadron of the Exploring Expedition, set sail from Norfolk under the command of Lieut. Charles Wilkes, U.S.N.

It was the first of the great undertakings in which the national munificence was employed in the cause of exploration at sea, and, although its fundamental purposes were to promote commerce and navigation, to diminish the hazards of the ocean, and to point out to future navigators a course by which they might avoid dangers and find safety, one of the primary aims was also to extend the bounds of science and promote the acquisition of knowledge.

An abundant instrumental equipment was procured from the best English, French and German makers, and a corps of scientists accompanied the expedition for the more successful attainment of its purposes.

The world has long known and benefited by the results of the labors of this Expedition in hydrography and geography, in astronomy and meteorology, in botany and horticulture, in philology, geology and biology. This will appear from the array of resulting scientific volumes for which the country is particularly indebted to the Joint Committees on Library of the Twenty-seventh and Twenty-eighth Congresses, to whose supervision the execution of the provisions for the publication of these works was entrusted.

---

* Map facing p. 80.

Senate Report No. 391 of the Thirty-fifth Congress, 2nd session, sets forth that the plan of the work embraced twenty-four volumes and fourteen atlases, and that, on March 3, 1859, there had been published:

The narrative of the Expedition, in five volumes with atlas; Philology (vol. 6), Zoophytes (vol. 7), with atlas; Ornithology and Mammalogy (vol. 8), with atlas ; Races of Men (vol. 9), Geology (vol. 10), with atlas; Meteorology (vol. 11), Mollusca (vol 12), with atlas; Crustacea (vols. 13 and 14), with two atlases; Botany (vol. 15), with atlas; Ferns (vol. 16), with atlas, and Herpetology (vol. 20), with atlas; further, there were nearly printed for publication: Botany, by Torrey (vol. 17), with atlas; Botany, by Gray (vol. 18), with atlas, and Hydrography (vol. 23), with two atlases; that the manuscript of the Geographical Distribution of Plants by Pickering (vol. 19) was complete; that the manuscripts of Ichthyology by Agassiz (vols. 21 and 22), with two atlases, were nearly ready, and that the volume on Physics (No. 24) was in progress.

Volumes 17 and 23 treating of Botany and Hydrography were subsequently published, but the printing of volumes 18, 19, 21 and 22 was never completed; and, when in 1876, Congress postponed indefinitely further steps in the publication, as shown by Senate Report No. 60, 44th Congress, 1st session, the contemplated volume on Physics does not appear to have emerged from the manuscript stage.

These unpublished observations, and the results which should have been derived from them, have thus far been lost to the world, and the Expedition worked in vain as far as any benefit has yet been derived from the pendulum, tidal, magnetic, and other physical results that were intended to be discussed and included in the volume on Physics.

The searches of thirty years did not reveal any trace of the manuscript records of these observations until fragments were recently found among the household papers of the descendants of Admiral Wilkes. Although they had been subjected to many vicissitudes in their removal from place to place with the family effects, it was possible, through the gracious kindness of the Misses Wilkes, to extract from them the material for a complete representation of the lines of magnetic inclination and declination in the approaches to the South Magnetic Pole and along the borders of the Antarctic Continent, from the facts of observation as recorded by observers equipped with magnetic instruments of the highest order of excellence, on board the four ships of that part of the Expedition which penetrated the Antarctic region.

The results of the discussion of the recovered observations have yielded the accompanying map, which shows, in addition to the lines of the variation of the compass or magnetic declination and the lines of dip or magnetic inclination for the epoch 1840, the edge of the icy barrier bordering the continent as plotted by the Americans. Such magnetic lines from original observations made long ago have a value which increases with the lapse of years on account of their importance in elucidating the changes which time works in altering the magnetic state of the earth.

Value would not attach to the recovery of the tidal observations and the records of the pendulum experiments in the same degree as to the magnetic observations, because, as the tides and the force of gravity in a given locality do not appear to change with the course of time, the loss of the records in relation to them might be made good by taking observations at any subsequent period at the same stations.

But it is not so with the elements of the earth's magnetism. The observations of them yields the record of a fleeting condition to which we can never reascend until the laws of their age-long changes come to be understood.

It will be remembered that, during the year 1839, after having examined many of the island groups with which the vast area of the Pacific Ocean is studded, the Exploring Expedition had reached the Australian shores. On the day after Christmas in 1839, the *Vincennes*, *Peacock*, *Porpoise* and *Flying Fish* headed southward from Sydney, and, falling in with the land in latitude 64° south and longitude 158° east of Greenwich, on the 16th of January following, skirted the border of a new continent to the eastward as far as longitude 97° east of Greenwich. Returning to Sydney, Wilkes announced his discovery in the following words, in a report to the Secretary of the Navy, dated March 11, 1840:

"It affords me much gratification to report that we have discovered a large body of land within the Antarctic Circle, which I have named the Antarctic Continent, and refer you to the report of our cruise and accompanying charts, enclosed herewith, for full information relative thereto."

During the cruise, in the opening months of 1840, the observations were taken which are now brought forward for discussion:

TAKEN ON BOARD THE SHIP VINCENNES

Date 1840.	Latitude South.	Longitude East.	Declination.	Inclination.	Needle.	Reference.
Jan. 11	63°–32′	164°–55′	23°–04′ E.	81°–24′–32″ S.	Gambey (.)	V. 1
				81 –11 –15	" (. .)	
Jan. 18	66 –08	154 –53	20 –00 E.	86 –28 –19	" (.)	V. 2
				86 –21 –00	" (. .)	
				83 –16 –30	" (.)	
				83 –08 –37	" (. .)	
Jan. 23	66 –47	148 –10	19 –06 E.	87 –42 –45	" (.)	V. 3
				87 –38 –15	" (. .)	
Jan. 25	67 –04	147 –30	11 –46 E.	87 –16 –15	" (.)	V. 4
				87 –12 –46	" (. .)	
Feb. 1	66 –15	138 –00	2 –30 W.	85 –30 –15	" (.)	V. 5
				85 –16 –05	" (. .)	
Feb. 7	64 –30	131 –30	7 –08 W.	84 –07 –30	" (.)	V. 6
				84 –09 –56	" (. .)	
Feb. 12	65 –10	112 –00	49 –30 W.	82 –20 –37	" (.)	V. 7
				81 –59 –03	" (. .)	
Feb. 14	66 –00	106 –14	59 –31 W.	82 –41 –15	" (.)	V. 8
				82 –15 –37	" (. .)	
Feb. 17	64 –00	97 –04	54 –39 W.	79 –09 –45	" (.)	V. 9
				80 –14 –00	" (. .)	

TAKEN ON BOARD THE BRIG PORPOISE

Date 1840.	Latitude South.	Longitude East.	Declination.	Inclination.	Needle.	Reference.
Jan. 9	58°–30′	163°–30′	21°–00′ E.	77°–42′.45 S.	Lloyd 1	P. 1
				78 –18 .75	" 2	
Jan. 11	64 –20	164 –20	25 –35 E.	82 –25 .00	" 1	P. 2
				82 –43 .75	" 2	
Jan. 12	64 –35	165 –40	27 –20 E.	82 –01 .80	" 1	P. 3
				82 –41 .25	" 2	
Jan. 13	65 –08	163 –51	30 –27 E.	83 –26 .25	" 1	P. 4
				82 –48 .45	" 2	
Jan. 15	66 –08	158 –20	32 –04 E.	83 –56 .25	" 1	P. 5
				83 –30 .00	" 2	
Jan. 17	66 –20	157 –00	26 –17 E.	84 –11 .25	" 1	P. 6
				84 –15 .00	" 2	
Jan. 22	66 –30	151 –40	22 –08 E.	85 –30 .00	" 1	P. 7
				85 –35 .62	" 2	
Jan. 23	66 –50	151 –25	21 –04 E.	85 –43 .12	" 1	P. 8
				85 –41 .25	" 2	
Feb. 1	64 –40	131 –00	9 –33 W.	85 –18 .75	" 1	P. 9
				85 –22 .50	" 2	
Feb. 9	64 –50	111 –00	46 –49 W.	83 –33 .75	" 1	P.10
				83 –18 .75	" 2	
Feb. 11	65 –35	106 –00	53 –16 W.	82 –22 .30	" 1	P.11
				82 –03 .52	" 2	
Feb. 13	64 –40	102 –00	55 –10 W.	81 –00 .00	" 1	P.12
				81 –00 .00	" 2	

TAKEN ON BOARD THE SHIP PEACOCK

Date 1840.	Latitude South.	Longitude East.	Declination.	Inclination.	Needle.	Reference.
Jan. 23	66°–52′	150°–24′–45″	15°–00′ E.	86°–10′	Robinson	H.
				86°–23′	Lloyd	

In consequence of the very near approach to the magnetic pole which the great amount of dip indicates, and the consequent curvature of the lines of equal dip, the observations are to be treated by gathering them together into groups so circumscribed that within the limits of each no important error could arise in considering the isoclinal line to coincide with its tangent. On inspecting the observations with this purpose, it was seen that, by leaving out of view the observations P. 1 and V. 9, the remainder might be arranged in four groups, each comprised within less than ten degrees of longitude, and of which the whole would be included within less than four degrees of latitude. Adopting this method, taking the mean of the readings of the needles of each set, and reducing the minutes to decimals of a degree, the arrangement of the groups is as follows:

GROUP A.

Reference.	Latitude.	Longitude.	Dip.
P. 3	64°–35′	165°–40′	82°.359
V. 1	63 –32	164 –55	81 .298
P. 2	64 –20	164 –20	82 .573
P. 4	65 –08	163 –51	83 .122
P. 5	66 –08	158 –20	83 .719
P. 6	66 –20	157 –00	84 .219

GROUP B.

Reference.	Latitude.	Longitude.	Dip.
V. 2	66°–08′	154°–53′	84°.810
P. 7	66 –30	151 –40	85 .547
P. 8	66 –50	151 –25	85 .705
H.	66 –52	150 –24 45″	86 .275
V. 3	66 –47	148 –10	87 .675
V. 4	67 –04	147 –30	87 .241

GROUP C.

V. 5	66 –15	138 –00	85 .386
V. 6	64 –30	131 –30	84 .145
P. 9	64 –40	131 –00	85 .344

GROUP D.

V. 7	65 –10	112 –00	82 .164
P. 10	64 –50	111 –00	83 .437
V. 8	66 –00	106 –14	82 .474
P. 11	65 –35	106 –00	82 .215
P. 12	64 –40	102 –00	81 .000

On examining group C, it is obvious by mere inspection that the observations P. 9, made on board the *Porpoise*, does not correspond with the other two, made on board the *Vincennes*. On trial it was found that the combination of these three would indicate a decrease of inclination with an increase of latitude, which is contradicted by all the other observations. As the probabilities appear to be in favor of the accuracy of the observations made on the *Vincennes*, the observation of the *Porpoise* has been rejected in the treatment of this group.

In group A, if we take as a central position a point in latitude 65°–30′ South and longitude 161°–30′ East, we have for the geographical co-ordinates of the places of observation:

Place.	Difference of Latitude.	Difference of Longitude.			
P. 3	— 55′	+4°.10 =	+107.2995	geographical	miles.
V. 1	—118	+3 .25 =	+ 91.3638	“	“
P. 2	— 70	+2 .50 =	+ 73.6329	“	“
P. 4	— 22	+2 .21 =	+ 59.2916	“	“
P. 5	+ 38	—3 .10 =	— 67.8758	“	“
P. 6	+ 50	—4 .30 =	—108.3821	“	“

Let. d = the difference between 81° and the dip or inclination at the central position.

" y = the increase of dip for each minute of latitude in fractions of a degree.

" x = the increase of dip for each geographical mile of longitude in fractions of a degree.

Then the following equations of condition may be formed:

$$\begin{array}{rclclcl}
-1.359 = & d & + & 107.2995 & x & - & 55\ y \\
-0.298 = & d & + & 91.3698 & x & - & 118\ y \\
-1.573 = & d & + & 73.6329 & x & - & 70\ y \\
-2.122 = & d & + & 59.2916 & x & - & 22\ y \\
-2.719 = & d & - & 67{,}8578 & x & + & 38\ y \\
-3.219 = & d & - & 108.3821 & x & + & 50\ y
\end{array}$$

Forming normal equations from these by the method of least squares, and solving for d, x, and y, we obtain:

$d = -2^\circ.353958$, and the dip at the central station $= 83^\circ.353958$

$x = -0^\circ.000795$

$y = -0^\circ.016706$

For the angle u, which the isoclinal line makes with the meridian, we have

$$\tan u = \frac{y}{x}$$

Whence $u = +\,87^\circ\text{-}16'\text{-}32''$.

Making the direction of the isoclinal line from N. 87°-16′-32″ E. to S. 87°-16′-32″ W.

Calculating the dips at the several stations from the above results, we obtain the following differences between the calculated and observed dips:

PLACE.	DIFFERENCE.
P. 3	—0°.161431
V. 1..........	—0°.157284
P. 2..........	+0°.329924
P. 4..........	+0°.088437
P. 5..........	+0°.215825
P. 6..........	+0°.115906

In group B, if we take as a central position a point in latitude 66°-30′ south and longitude 151° east, we have for the co-ordinates of the places of observation:

Place.	Difference of Latitude.	Difference of Longitude in Geographical Miles.
V. 2...........	—22′	+94.2740
P. 7...........	0	+15.9500
P. 8...........	+20	+ 9.8352
H.	+22	—13.8487
V. 3..........	+17	—67.0156
V. 4...........	+34	—81.8236

Treating these in the manner just illustrated in relation to group A, we obtain

$d = -2.301293$, and the dip at the central position $86^\circ.301293$
$x = +0.022106$
$y = +0.021807$
$u = +43^\circ\text{-}38'\text{-}55''$

For the differences between the observed and calculated dips in this group, we have:

PLACE.	DIFFERENCE.
V. 2...........	+0.128814
P. 7...........	−0.401702
P. 8...........	+0.042864
H.	+0.131482
V. 3...........	+0.250739
V. 4...........	−0.152598

Of group C we retain only the observations designated V. 5 and V. 6. The calculations made from these give the following results for a central position in latitude 63°-30′ south and longitude 135° east.

$d = 0.854107$, and the dip at the central position $= 84^\circ.854107$
$x = 0.000000$
$y = +0.011815$
$u = 90^\circ$

whence the difference between the observed and calculated values of the dip become

−0.000180
+0.000207

In group D the following results were obtained for a central position in latitude 65° south and longitude 107° east.

$d = 1.1071529$, and the dip at the central position $= 82^\circ.1071529$
$x = -0.0062103$
$y = +0.0054502$
$u = -41^\circ\text{-}16'\text{-}13''$

The differences between the observed and calculated values of the dip are:

PLACE.	DIFFERENCE.
V. 7....... ..	−0.7801154
P. 10.........	+0.7505259
V. 8.........	+0.1560298
P. 11.........	+0.0711197
P. 12.........	−0.2058669

If we consider that the probable position of the south magnetic pole could be found by means of the intersection of the normals to the isoclinal lines, the groups B, C, and D would furnish a remarkable result. Upon a polar gnomonic projection the three directions converge almost to one point. The direction of the normal of group A will not, however, intersect that of B on the southern side of the isoclinal line.

The computed position of the magnetic pole, from a combination of groups B and C, was

Latitude 68°–56′–15″ south, Longitude 135° east;

and, from a combination of groups C and D,

Latitude 68°–42′–07″ south, Longitude 135° east.

The isoclinal lines would appear from inspection of the values of u, in the four separate groups to be curves of contrary flexure, changing the direction of their curvature between the groups A and C, and thence forming an oval, concave toward the south. Calculation further shows that the magnetic polar distances of the central points of the four groups A, B, C, and D are, respectively, 12°–48′–04″, 7°–22′–04″, 12°–38′–30″, and 15°–29′–56″, and the average of these would indicate that the magnetic pole was in latitude 77°–12′ south.

The highest dip observed by Wilkes was 87°–40′, and the compasses on the ice were very sluggish, pointing 19°–06′ east of the meridian as accurately as could be determined; this was in longitude 148°–10′ east and latitude 66°–47′ south.

The indications would point to the fact that the south magnetic pole was not then a mere point, but that there must have been a large irregular area over which the dipping needle stood vertical or very near vertical.

The observations for the variation of the compass or magnetic declination are so numerous that after plotting all of them the isogonic lines could be drawn very readily with the help of the variation lines laid down upon the chart of the Antarctic Continent in volume I of the Atlas of Charts accompanying the volume on Hydrography of the Exploring Expedition; and they are thus included in the accompanying map of Magnetic Declination and Inclination in the Approaches to the South Magnetic Pole.